$PV = NkT$, $E = fNkT = fPV$: $N = 6.02\times10^{23}$, $k = 1.38\times10^{-23}$ J/K

$\left(P + \frac{N^2}{V^2}a\right)(V - Nb) = NkT$, $E = \frac{3}{2}NkT - \frac{aN^2}{V}$: $\gamma = \frac{C_P}{C_V}$

$PV^{\gamma} = \text{Const.}$: $TP^{(1-\gamma)/\gamma} = \text{const.}$: $TV^{(\gamma-1)} = \text{const.}$

$K = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$, $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$, $dE = TdS - PdV + \mu dN$

$Q = mC\Delta T$, $\delta Q = TdS$, $\Delta E = C\Delta T$, $W = -\int P(V)\,dV$

$\delta Q = \left[P + \left(\frac{\partial E}{\partial V}\right) + \left(\frac{\partial P}{\partial V}\right)\left(\frac{\partial E}{\partial P}\right)\right] dV$

$H = E + PV$, $G = E - TS + PV$, $F = E - TS$, $W_{by} \le -\Delta F$

$\eta = \left|\frac{W_{net}}{Q_+}\right| = 1 - \left(\frac{V_f}{V_i}\right)^{\gamma-1}$, $\eta \le 1 - \frac{T_L}{T_H}$

$\left(\frac{\partial z}{\partial y}\right)_x = -\left(\frac{\partial z}{\partial x}\right)_y\left(\frac{\partial x}{\partial y}\right)_z$, $\left(\frac{\partial x}{\partial y}\right)_z\left(\frac{\partial y}{\partial z}\right)_x\left(\frac{\partial z}{\partial x}\right)_y = -1$

$\frac{1}{T} = \left(\frac{\partial S}{\partial E}\right)_{V,N}$, $\frac{P}{T} = \left(\frac{\partial S}{\partial V}\right)_{E,N}$, $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$

$C_P = \left(\frac{\partial H}{\partial T}\right)_P$, $C_P = \left(\frac{\partial E}{\partial T}\right)_P + P\left(\frac{\partial V}{\partial T}\right)_P$, $C_P = C_V + TV\frac{\alpha^2}{K}$

$C_V = \left(\frac{\partial E}{\partial T}\right)_V$, $C_V = \left(\frac{\partial H}{\partial T}\right)_V - V\left(\frac{\partial P}{\partial T}\right)_V$

Gas $\rightarrow \Delta S = \int_{T_i}^{T_f}\frac{C_V}{T}dT$, $\Delta S = \int_{T_i}^{T_f}\frac{C_P}{T}dT$, $\Delta S = \frac{Q}{T} = \frac{mC\Delta T}{T}$ Bath

$S = fNk\ln(T_i) + Nk\ln(V_i) + \tilde{h}(N)$

No W_{nm} on system : $\Delta G \le W_{nm}$: W_{nm} on system : $-\Delta G \le W_{nm}$

$\bar{x} = \sum x_i \cdot P_i(x_i)$, $\overline{x^2} = \sum x_i^2 \cdot P_i(x_i)$, $\sigma = \sqrt{(\overline{x^2}) - (\bar{x})^2}$, $P(k) = \binom{N}{k}p^k q^{N-k}$, Prob (macrostate) $= \frac{\Omega(N_+)}{\#\text{ microstates}}$: $p = q = 1/2$

$E = -BM$, $M = \mu(N_+ - N_-)$, $\bar{N}_\pm = NP_\pm$, $\overline{N^2}_\pm = \bar{N}_\pm^2 + NP_+P_-$, $\Omega(N,q) = \binom{N+q-1}{q} = \frac{(N+q-1)!}{q!(N-1)!}$, $E = \hbar\omega(q + N/2)$

$\Omega = \Omega_A\Omega_B$, $\ln(N!) \approx N\ln(N) - N + \frac{1}{2}\ln(2\pi N)$, $N! \approx N^N e^{-N}\sqrt{2\pi N}$, $\left(1 + \frac{x}{n}\right)^n \approx e^x$, $S = k\ln[\Omega]$

$\Gamma(E) = \#$ of microstates, $E = \frac{h^2}{8mL^2}(n_x^2 + n_y^2 + n_z^2)$, $P = \frac{e^{-\beta E}}{Z}$, $Z = \sum e^{-E_s\beta}$, $\bar{E} = -\frac{\partial}{\partial\beta}\ln(Z)$, $C = \frac{\partial\bar{E}}{\partial T}$

$S = k\ln[g(E)\,dE]$

$P_{speed}(v) = 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-v^2 m/2kT} = \alpha v^2 e^{-v^2\gamma}$, $Z_{single} = \alpha\int e^{-(P_x^2+P_y^2+P_z^2)\beta/2m}\,dp_x\,dp_y\,dp_z$

$\bar{n}_k = \frac{1}{e^{(\epsilon-\mu)\beta} - 1} \rightarrow$ Bosons, $\bar{n}_k = \frac{1}{e^{(\epsilon-\mu)\beta} + 1} \rightarrow$ Fermions

$\bar{v} = \alpha\int_0^\infty v\,P(v)$, Avg. K.E. $\bar{v^2} = \alpha\int_0^\infty v^2 P(v)$